# Time of Pediatric Intensive Care Unit Admission and Mortality: A Systematic Review and Meta-Analysis

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## Abstract

The aim of this study was to determine the association between the time of admission (day, night, and/or weekends) and mortality among critically ill children admitted to a pediatric intensive care unit (PICU). Electronic databases that were searched include PubMed, Embase, Web of Science, CINAHL (Cumulative Index of Nursing and Allied Health Literature), Ovid, and Cochrane Library since inception till June 15, 2018. The article included observational studies reporting inhospital mortality and the time of admission to PICU limited to patients aged younger than 18 years. Meta-analysis was performed by a frequentist approach with both fixed and random effect models. The GRADE (Grading of Recommendations Assessment, Development, and Evaluation) approach was used to evaluate the quality of evidence. Ten studies met our inclusion criteria. Five studies comparing weekday with weekend admissions showed better odds of survival on weekdays (odds ratio [OR]: 0.77; 95% confidence interval [CI]: 0.60–0.99). Pooled data of four studies showed that odds of mortality were similar between day and night admissions (OR: 0.93; 95% CI: 0.77–1.13). Similarly, three studies comparing admission during off-hours versus regular hours did not show better odds of survival during regular hours (OR: 0.77; 95% CI: 0.57–1.05). Heterogeneity was significant due to variable sample sizes and time period. Inconsistency in adjusting for confounders across the included studies precluded us from analyzing the adjusted risk of mortality. Weekday admissions to PICU were associated with lesser odds of mortality. No significant differences in the odds of mortality were found between admissions during day versus night or between admission during regular hours and that during off-hours. However, the evidence is of low quality and requires larger prospective studies.

**Keywords**
- pediatric
- intensive care
- critical care
- time of admission
- mortality

## Introduction

Timely admission of a critically ill child to a pediatric intensive care unit (PICU) is a crucial determinant of outcome.[1–3] Admission to PICU depends on several factors ranging from acuity, severity, and reversibility of illness, to the overall prognosis of the primary disease process.[4,5] In resource-limited settings, limitations such as bed availability and expenditure may be important determinants.[4] Admission to any PICU occurs throughout the day and night. The PICU team is therefore expected to be alert and prepared at all times to receive, resuscitate, and stabilize the admissions

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followed by a vigilant monitoring for disease progression and complications. However, several factors can hinder the delivery of appropriate care, thus increasing patient mortality.

Timing of PICU admission is one such factor. Admission during off-hours may predispose to poor outcome owing to factors such as increased severity of illness, absence of in-house intensivist, inaccessibility to emergent/lifesaving procedures, low staff-to-patient ratio, impaired circadian rhythm, and fatigue of team members.[6–11] Adult studies have demonstrated a significant impact on mortality during off-hour admissions.[3,12–14] Cavallazzi et al in their meta-analysis of critically ill adults found increased mortality during weekend admissions. However, no such relation was observed with night admissions.[15] Galloway et al reported similar findings in their recent meta-analysis of greater risk-adjusted mortality for ICU weekend admissions compared with weekday admissions. Presence of an in-house intensivist during night admissions was found to be associated with decreased mortality.[16]

Data with regard to children are, however, inconclusive; observational studies have reported variable results and poor outcomes with respect to off-hour admissions.[1,2,9,11,17–23] The observed variations in outcome were possibly related to a difference in the population characteristics admitted during off-hours rather than a difference in PICU care.[3,19] Seasonal variations have also been shown to be associated with mortality.[20] The staffing pattern and intensivist coverage during off-hours may also be a contributory factor. Despite the variability in findings, a robust systematic review to determine the association between time of admission and inhospital mortality in children has not been undertaken. We believe the data generated by this analysis will aid policy decisions with respect to PICU admission guidelines, intensivist coverage, and staff facility during weekends and off-hours.

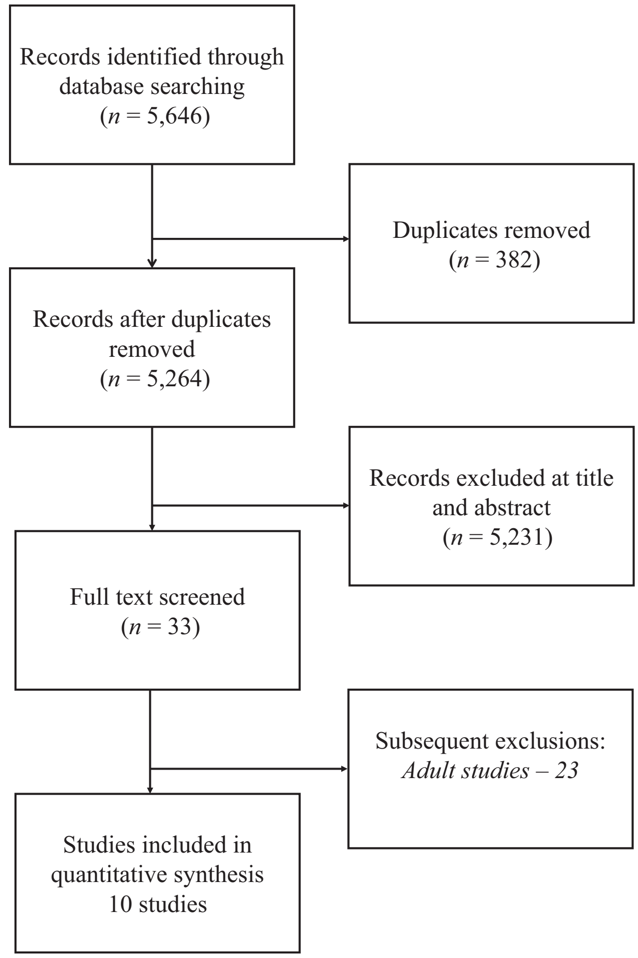


**Fig. 1** A PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow chart demonstrating the selection strategy to identify pediatric studies related to the time of admission and pediatric intensive care unit mortality.

## Methods

We followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines for this systematic review (►**Fig. 1**).[24] The review was registered in PROSPERO (CRD42018099861).

### Selection Criteria for the Studies

All observational studies (S-study design) of children younger than 18 years (P-population) admitted to PICU during off-hours and weekends (E- exposure) were compared with the studies of admissions during regular hours (C-comparison) to determine the effect on mortality (O-outcome).

The definitions of "off-hours" and "weekend" were clearly defined in the included studies. "Regular hours" were defined as routine timings others than off-hours and weekends. Patient demographics, admission diagnosis, case type (medical/surgical), day and time of admission, severity of illness scoring, presence/duration of an intensivist cover, number of admissions per year/month, bed status, nurse-to-patient ratio, and ICU mortality were noted if available. Epidemiological studies conducted during disease outbreaks and natural disasters were excluded.

### Search Strategy

We formulated the search strategy using the MeSH terminology, which was then adapted for the databases being searched. We used the keywords "pediatric," "children," "sick," "critical care," "intensive care unit," "time," "admission" and "off hours," "night time," "weekends," "mortality," and "death" to search for studies. No language restrictions were applied. Various databases searched were, such as PubMed, Embase, CINAHL (Cumulative Index of Nursing and Allied Health Literature), Web of Science, Cochrane Library, and Ovid from their inception to June 15, 2018. The searches were updated as of January 2019. We also screened the bibliography of all the potentially relevant articles.

### Data Collection and Analysis

The search results were exported to a reference manager (EndNote, Clarivate Analytics, Philadelphia, United States), and all duplications were removed. Two reviewers (V.W., N.J.) independently scanned the title, abstract, or both for every record retrieved to shortlist the studies that needed further assessment. Discrepancies were resolved through consensus or recourse to a third review author (M.S./M.J.). The full-text articles of the selected titles were then obtained and screened for inclusion. All studies that met the inclusion criteria were labeled as included, and the rest were excluded. The studies included are presented in a PRISMA flowchart (►Fig. 1).

Three review authors (V.W., N.J., A.C.) independently extracted key data from the included studies with respect to study characteristics and outcome measures using a standard data extraction template. We contacted the authors of the included studies for information regarding missing data and clarifications if any. We used the Newcastle–Ottawa Scale (NOS) for assessing the risk of bias of the included studies. The GRADE (Grading of Recommendations Assessment, Development, and Evaluation) approach was used to assess the quality of evidence. Analysis was performed using Stata version 12 (Stata Corp., College Station, Texas, United States). Unadjusted all-cause mortality during hospital stay was compared for off-hour versus regular hour, weekend versus weekday, and day versus night admissions. For each study, we calculated odds ratios (ORs) and 95% confidence intervals (CIs) for mortality. Pooling of data, where possible, was performed using the random-effects model (►Fig. 2). Egger's regression plot was used to ascertain the effect of small studies and publication bias (►Fig. 3). We assessed consistency using both $\chi^2$ test and $I^2$ statistic.

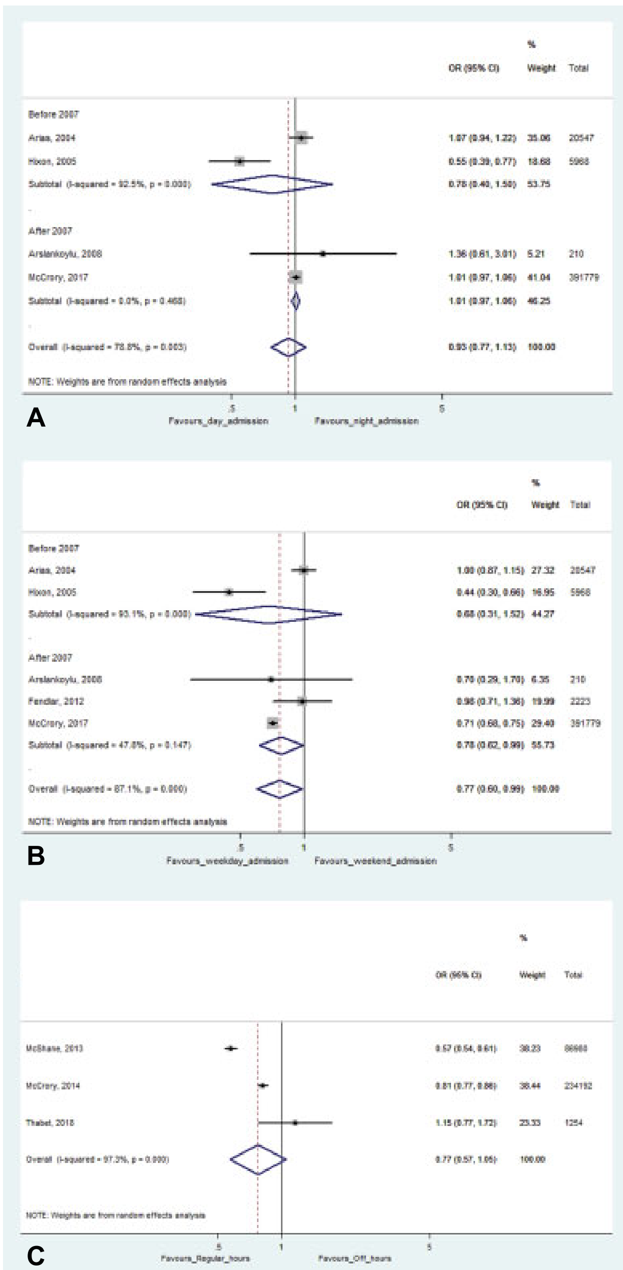


**Fig. 2** A forest plot showing the association between time of admission and pediatric intensive care unit mortality. **(A)** Comparison of day versus night admission. **(B)** Comparison of weekday versus weekend admission. (**C**) Comparison of regular versus off-hour admission.

## Results

We identified a total of 5,646 citations, of which 5,264 remained once duplications were removed. After exclusion of articles during title and abstract screening, we identified 33 articles as eligible. Of these, 23 were adult studies[6–8,10,12–14,25–40] and hence excluded (►Fig. 1). This left us with 10 studies over a period of 20 years (1995–2015)

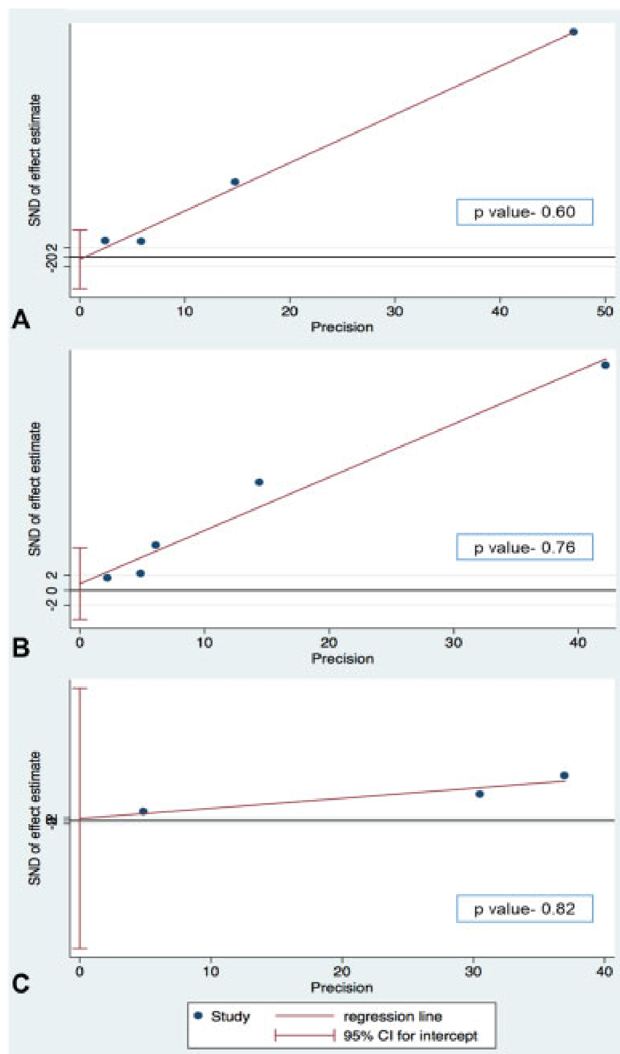


**Fig. 3** Egger's regression plots for comparing precision of individual studies. CI, confidence interval; SND, Standard normal distribution.

for this review. Of these, four were multicenter and six were single-center studies. The characteristics of these studies are shown in ►**Table 1**. Two were prospective studies,[11,18] and the rest were retrospective observational studies. Four studies were from the United States,[1,9,17,22] three from Europe,[19,20,23] two from the Middle East,[2,11] and one from Australia.[18] Study duration varied from 6 months to 12 years. Night versus day admissions and mortality were seen in four studies,[1,2,17,22] whereas weekends versus weekdays were seen in five studies[1,2,17,22,23] and off-hours (night and weekends) with regular hours in three.[9,11,20] Definition of start of day admission varied from 6 a.m. to 8 a.m. and that of night admission varied from 5 p.m. to 8 p.m. Weekends included Saturday and Sunday with similar day and nighttime intervals, except one study in which Friday and Saturday were considered as weekends as per country norm.[11]

The differences in staffing pattern in the included studies are given in ►**Table 2**. Two model of PICU care described include the "on-demand model," in which the intensivist was called only when needed, and the "$24 \times 7$ model," in which an intensivist was present round the clock. Six studies had an on-demand model, one study had a $24 \times 7$ intensivist coverage model, and two studies had both models. However, many studies that had an on-demand model had a good back up with registrars, fellows, and pediatric nurse practitioners. Risk adjustment for individual studies with their OR is tabulated in ►**Table 3**. Quality assessment of individual studies performed using the NOS (►**Table 4**) suggested that the risk of bias was less in the included studies. The GRADE approach revealed low-quality evidence of the individual studies (►**Table 5**). Severity of illness was higher during night and off-hour admissions. As different severity scores (PIM2, PRISM II, PRISM III) were used, pooling of data by posthoc analysis to look for differences in adjusted mortality could not be performed.

Our random-effects model (►**Fig. 2**) showed no significant difference in mortality in day versus night admissions or in regular versus off-hour admissions to the PICU. Pooled OR (95% CI) for day versus night admission and for regular versus off-hours were 0.93 (0.77–1.13) and 0.77 (0.57–1.05), respectively. Pooled OR (95% CI) for weekday versus weekend admission was 0.77 (0.60–0.99), thus favoring weekday admissions.

Studies were also divided into two epochs of 10 years each to determine if time period made a difference (Epoch 1: before 2007; Epoch 2: after 2007). We found that both epochs were similar with respect to mortality in day versus night admissions. However, epoch 2 favored weekday admissions as compared with epoch 1, which was similar for weekday and weekend. All studies that compared regular versus off-hour admissions were in epoch 2. Studies conducted in epoch 2 were less heterogeneous as compared with epoch 1.

## Discussion

In this systematic review, we found that weekend admissions were associated with increased odds of mortality. However, night time or off-hour admissions to PICU were not associated with increased mortality. Our findings in critically ill children were similar to adults, in whom a higher mortality rate was observed during weekend admissions.[15,16]

Timely admission to an intensive care facility is essential for critically ill. Delayed intensive care admission is a well-known factor for increased mortality.[41,42] There are several barriers to timely intensive care admission, including patient factors, disease severity, initial stabilization, transport, and bed availability.

### Time of the Day

Studies over the last two decades have shown higher neonatal, pediatric, and adult deaths during night admissions.[14,17,43] However, factors causing mortality were not completely analyzed. However, this finding has not been uniform in all studies; one study showed increased odds of death during night admissions,[17] whereas another did not find any difference in the risk of adjusted mortality.[1] This divergent result was possibly related to differences in the structure, delivery of care, or both. Staffing inequality with low doctor-to-patient ratio, complications during surgery, or difficult surgery with delayed transfer back to the intensive care unit (ICU) were some of the attributable causes for this higher mortality.[19] Recent studies with a larger sample size did not show any significant difference in mortality probably related to better staffing pattern and implementation of a $24 \times 7$ model of intensivist cover in these ICUs.[9,22] Our pooled analysis did not reveal any difference in unadjusted mortality during night admissions.

Early morning hours from 6 a.m. to 11 a.m. were shown to have a higher mortality rate, reason being that this time slot coincides with handover time and consultant rounds. Moreover, those patients who either missed or deteriorated at night often tend to be shifted to ICU early morning. Similar trends of peak mortality during morning hours were reported by adult studies.[13,27,28] Handover time as a risk factor for increased mortality needs to be evaluated further.

### Day of the Week

Of the five studies analyzed, two showed weekend admissions to be associated with increased mortality, whereas three studies did not demonstrate this association.[1,22] Our meta-analysis showed reduced mortality during weekday admissions. Studies in neonates have also shown that perinatal morbidity and mortality were higher during nighttime, weekends, and off-hours.[43,44] This could be attributed to a number of factors including a higher number of high-risk admissions, patient health-seeking behavior, socioeconomic status and lifestyle, and differences in the quality of care provided.[2,17,23] The differences in the pattern of referral to a higher center may be another important factor. This difference observed may be related to low staffing in a certain ICU on weekends and the inability to initiate certain lifesaving interventions such as extracorporeal membrane oxygenation, which may not be immediately available during weekends. The staffing pattern may vary in different countries as per their norms. However, whether a low staffing pattern and lack of intensivist cover be attributed to this increased mortality is still questionable unless adjusted for other confounders.

**Table 1** Characteristics of the included studies

| Study | Type | Country | Setting | Study period | Duration | Nature of admission | Sample size | Age group | Definition | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Day | Weekend | Off-hours |
| Arias et al[17] | Retrospective | United States | Multicenter (15 PICU) | May 1995 to December 2001 | 6 y | E | 20,547 | NM | 7.00–17.00 (Monday to Sunday) | 19.00 (Friday) to 7.00 (Monday) | NA |
| Hixson et al[1] | Retrospective | United States | Single center (14-bedded) | August 1996 to December 2003 | 7 y 4 mo | All (E: 36%; P: 64%) | 5,968 | 0–21 y | 7.00–19.00 (Monday to Sunday) | Saturday, Sunday (7.00–7.00) | NA |
| Arslankoylu et al[2] | Retrospective | Turkey | Single center (10-bedded) | November 2005 to April 2006 | 6 mo | All (E: 67.1%; P: 32.9%) | 210 | 1 m to 18 y | 8.00–17.00 (Monday to Sunday) | Saturday, Sunday | NA |
| Numa et al[18] | Prospective | Australia | Single center (12-bedded) | 1997–2006 | 10 y | E | 4,456 | 0–14 y | 8.00–18.00 (Monday to Friday) | Saturday, Sunday | 18.00–6.00 (Monday to Friday) and 12.00–6.00 (Saturday, Sunday) |
| Brown et al[19] | Retrospective | United Kingdom | Single center | March 2003 to April 2007 | 4 y | Cardiac (E and P) | 2,799 | NM | 8.00–19.59 (Monday to Sunday) | NA | NA |
| Fendler et al[23] | Retrospective | Poland | Single center | January 1999 to December 2007 | 9 y | All | 2,223 | NM (61.9% neonatal, 38.1% pediatric) | NA | Saturday, Sunday | NA |
| McShane et al[20] | Retrospective | United Kingdom | Multicenter (29 PICU) | January 2006 to December 2011 | 6 y | All (E: 58.4%; P: 41.6%) | 86,980 | NM | NA | NA | 17.00 (Friday))to 7.00 (Monday), Nighttime (20.00–8.00), or Bank holiday (17.00 hours prior to holiday 7.00 hours postholiday) |
| McCrory et al[9] | Retrospective | United States | Multicenter (99 PICU) | January 2009 to September 2012 | 3 y 9 mo | All | 234,192 | < 18 y | 7.00–19.00 (Monday to Friday) | 12 a.m. (Saturday) to 11.59 p.m. (Sunday) | Nighttime (19.00–7.00) and weekend (Saturday, Sunday anytime) |
| McCrory et al[22] | Retrospective | United States | Multicenter (129 PICU) | 2009–2014 | 5 y | All | 391,779 | < 18 y | 6.00–18.00 (Monday to Sunday) | Saturday, Sunday | NA |
| Thabet et al[11] | Prospective | Saudi Arabia | Single center (34-bedded) | January 2012 to June 2015 | 2 y 6 mo | E | 1,254 | 0–14 y | 7.30–16.30 (Sunday to Thursday) | Friday, Saturday | Nighttime 16.30 to 7.30, Friday, Saturday |

Abbreviations: E, emergency; NA, not analyzed; NM, not mentioned; P, planned; PICU, pediatric Intensive care unit.

**Table 2** Staffing pattern in various studies

| Study | Intensivist model | Regular hour staffing | Off-hour staffing |
|---|---|---|---|
| Arias et al[17] | Not mentioned | Not mentioned | Not mentioned |
| Hixson et al[1] | 24 × 7 model | One attending intensivist (24 × 7)<br>One backup intensivist on demand<br>One to three residents<br>One pediatric nurse practitioner with fellows at varying levels | One attending intensivist (24 × 7)<br>One residents<br>One pediatric nurse practitioner<br>One additional on-call intensivist offsite |
| Arslankoylu et al[2] | On demand | Intensivist present at day time and on call at night | Intensivist present on call |
| Numa et al[18] | On demand | One attending intensivist (08:00–18:00)<br>Two registrars (3 y of training in pediatrics, emergency medicine, or anesthesia) from 08:00 to 21:00.<br>One nurse for each ventilated patient and one nurse for every two nonventilated patients<br>One ICU fellow acts as first-on-call from home (with intensivist backup) from 08:00 to 18:00 | One attending intensivist (08:00–12:00 and public holidays)<br>Two registrars<br>One nurse for each ventilated patient and one nurse for every two nonventilated patients<br>ICU fellow does not cover for weekend or public holiday |
| Brown et al[19] | On demand | One attending intensivist (08:00–20:00)<br>Two to three registrars<br>Total resident hours: 74.2% | Two registrars<br>Intensivist: on call<br>Total resident hours: 25.8% |
| Fendler et al[23] | On demand | Intensivist: not mentioned<br>three physicians on site | Intensivist: not mentioned<br>One or two physicians on site |
| McShane et al[20] | On demand | Predominantly midcareer grade physicians | 10–20% lower than daytime hours with a reduced ratio of nurses/occupied bed |
| McCrory et al[9] | Mixed (on demand and 24 × 7) | In-house, 24 × 7 staffing by a pediatric intensive care attending intensivist was present in 55/99 (56%) centers for at least part of the study period (45% for the entire period) | |
| McCrory et al[22] | Mixed (on demand and 24 × 7) | In-house, 24 × 7 staffing by a pediatric intensive care attending intensivist was present in 72/129 (56%) centers for at least part of the study period (43% for the entire period) | |
| Thabet et al[11] | On demand | One attending intensivist<br>One pediatric critical care fellow<br>One pediatric resident<br>The nurse-to-patient ratio is 1:1 in the ICU and 1:2 in the high dependency unit | One pediatric critical care fellow<br>One pediatric resident<br>Intensivists on call |

Abbreviation: ICU, intensive care unit.

## Regular versus Off-Hours

Off-hour admissions have a greater propensity toward unplanned emergency admissions, emergent intubations, and medication errors.[45,46] The results of regular versus off-hours and an increased risk of mortality have, however, been conflicting. Two large studies showed significantly lower odds of unadjusted mortality during regular hours.[9,20] On the other hand, one recent prospective study by Thabet et al[11] failed to demonstrate any difference. Our pooled results did not favor regular hour admissions.

## On-Demand Model versus 24 × 7 Intensivist Model

Studies using controls having no intensivists cover for comparison showed that the introduction of 24-hour intensivist cover was associated with improved outcomes in adult ICUs.[47–49] Pronovost et al in their meta-analysis of 24 adult and 3 pediatric studies reviewing staffing pattern and outcome found a beneficial effect of high-intensity staffing model.[3] Few prospective studies, however, have refuted the benefit of a 24 × 7 model staffing.[50,51] Kerlin et al in their randomized trial disproved the added mortality benefit with an intensivist presence at night.[51] However, lack of mortality benefit should not be the only parameter to oppose the 24 × 7 model. It has several other benefits such as improved decision making, supervision and training of residents, addressing parental concerns, facilitating early discharge by titration, and weaning of support, thus reducing PICU stay. Although its benefits outweigh the risks, balancing the provision of manpower and cost-effectiveness, especially in developing economies and low-volume centers, is a challenge.

Among the pediatric studies, Numa et al found no relation to such intensivist cover; in fact, the odds of mortality were 29% lower in off-hour admission. Their junior staff who managed the admission during off-hours were well-trained residents with at least 3 years of experience. Though the hypothesis that better care, monitoring, and early weaning are plausible explanations, one must remember that the overall quality of pediatric intensive care has improved tremendously over the years. The comparison of two competing staffing models (24 × 7 in-house versus on-demand

**Table 3** Risk adjustment used in studies and adjusted odds ratio

| Study | Factors adjusted | Adjusted odds ratio | | |
|---|---|---|---|---|
| | | Weekend vs. weekday | Night vs. day | Off-hours vs. regular hours |
| Arias et al[17] | Age, gender, PRISM III, previous PICU admission, need of vasoactive, need for ventilation | 1.00 (0.78–1.28) | 1.28 (1.00–1.62) | NA |
| Hixson et al[1] | Age, PRISM III, CPR status, primary diagnosis, intensivist presence | Not significant | Not significant | NA |
| Arslankoylu et al[2] | Gender, PIM2, need for ventilation, origin of admission | Not significant | Not significant | NA |
| Numa et al[18] | PIM2, intensivist presence | NA | NA | 0.712 (0.51–0.98) |
| Brown et al[19] | PIM2, origin of admission | 8 a.m. to 2 p.m.: 0.61 (0.50–0.74) | 8 p.m. to 2 a.m.: 2.53 (2.00–3.21) | NA |
| | | 2 p.m. to 8 p.m.: 0.70 (0.59–0.83) | 2 a.m. to 8 a.m.: 3.38 (2.42–4.72) | |
| Fendler et al[23] | Age | 0.97 (0.54–1.75) | NA | NA |
| McShane et al[20] | Age, gender, ethnicity, year of admission, PIM2, primary diagnosis | 1.05 (0.975–1.135) | 1.03 (0.96–1.11) | 1.1 (1.02–1.2) |
| McCrory et al[9] | Age, gender, PIM2, origin of admission, trauma status, intensivist presence | NA | NA | 0.91 (0.85–0.97) |
| McCrory et al[22] | Age, gender, PIM2, origin of admission, trauma status, intensivist presence | Admission throughout the weekend from 06:00 to 17:59 had increased odds of death | Admissions between 6.00 and 9.59 had increased odds of death 1.13 (1.01–1.27) | NA |
| Thabet et al[11] | Age, gender, PRISM II score, diagnosis | NA | NA | 0.85 (0.57–1.27) |

Abbreviations: CPR, cardiopulmonary resuscitation; NA, not analyzed; PICU, pediatric intensive care unit; PIM, pediatric index of mortality; PRISM, Pediatric Risk of Mortality.
Note: Data are presented as odds ratio (95% confidence interval).

coverage after hours) in two ICUs staffed by similarly trained intensivists and junior staff treating comparable patients would be a better model to delineate such differences. We believe that a well-organized PICU with a qualified team in a low-volume area may benefit from an on-demand model compared with a high-volume center that definitely warrants a 24 × 7 model.

## Completeness of the Review and Comparison with Other Studies

The systematic review has attempted to gather the information and provide a comprehensive overview of the current situation. The review has compared the mortality between off-hours and regular hours. This division of hours is based on the availability of all the regular health care staff including the intensivists; the off-hours refer to the nonavailability of support staff. This review indirectly also unveils the effect of availability of intensivists and other staff.

## Strengths and Weaknesses

A clearly defined protocol was used to conduct this review with prior registration to minimize concerns of internal validity. Database search was extensive, and to the best of our knowledge, none of the eligible studies was missed. Our findings are consistent with adult studies that suggest a similar association between increased mortality and weekend and off-hour admissions to the PICU. These findings were consistent across different countries and different health systems. Disease severity and other confounders were also assessed in a majority of the included studies. There was no publication bias detected in our study. Significant heterogeneity noted in our study was because of the differences in effect sizes and different time span of the included studies rather than differences in the direction of the effect.

This review has certain limitations inherent to the retrospective and cohort nature of the individual studies, thus precluding establishment of causality. However, in the absence of controlled trials, which could have thrown better light, this is the best available evidence that one can offer. Identifying factors that affect patient outcomes is essential to bring about improvement. Since different risk factors were evaluated in different studies, pooling of adjusted odds could not be performed. Patient-related factors such as etiology, delayed presentation, and type of referral are important parameters that could not be assessed. No data are available on the role of ancillary staff, and its significance remains

**Table 4** The Newcastle–Ottawa Quality Assessment Scale for the included cohort studies

| Quality assessment criteria | Acceptable* | Arias et al[17] | Hixson et al[1] | Arslankoylu et al[2] | Numa et al[18] | Brown et al[19] | Fendler et al[23] | McShane et al[20] | McCrory et al[9] | McCrory et al[22] | Thabet et al[11] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Selection** | | | | | | | | | | | |
| Representativeness of the exposed cohort? | Representative of children admitted to the PICU (age/sex/ being at risk of disease) | * | * | * | * | * | * | * | * | * | * |
| Selection of the nonexposed cohort? | Selected from the same community as the exposed cohort | * | * | * | * | * | * | * | * | * | * |
| Ascertainment of exposure? | Secured records, database, structured interview | * | * | * | * | * | * | * | * | * | * |
| Demonstration that the outcome of interest was not present at the start of study? | Yes | * | * | * | * | * | * | * | * | * | * |
| **Comparability** | | | | | | | | | | | |
| Study controls for age? | Yes | * | * | * | * | * | * | * | * | * | * |
| Study controls for at least three additional risk factors? | Gender, ethnicity, previous PICU admission, intensivist coverage, primary diagnosis, severity score (PRISM 3/ PIM2), vasoactive requirement, need for ventilation, CPR status | * | * | * | | | | * | * | * | * |
| **Outcome** | | | | | | | | | | | |
| Assessment of outcome? | Independent blind assessment, record linkage | * | * | * | * | * | * | * | * | * | * |
| Was follow-up long enough for the outcome to occur? | Till hospital discharge | * | * | * | * | * | * | * | * | * | * |
| Adequacy of follow-up of cohorts? | Complete follow-up or subjects lost to follow-up unlikely to introduce bias | | | * | * | * | * | * | * | * | * |
| Overall quality score (maximum = 9) | | 8 | 8 | 9 | 8 | 8 | 8 | 9 | 9 | 9 | 9 |

Abbreviations: CPR, cardiopulmonary resuscitation; PICU, pediatric intensive care unit; PIM, pediatric index of mortality; PRISM, Pediatric Risk of Mortality.
Note: Asterisk represents if individual criterion within the subsection was fulfilled.

**Table 5** Quality appraisal of studies using the GRADE approach

| Certainty assessment | | | | | | | | Certainty |
|---|---|---|---|---|---|---|---|---|
| Admission type | No. of studies | Study design | Risk of bias | Inconsistency | Indirectness | Imprecision | Other considerations | |
| Regular vs. off-hours | 3 | Observational studies | Not serious | Serious[a] | Not serious | Not serious | All plausible residual confounding would suggest a spurious effect, whereas no effect was observed[b] | ⊕⊕◯◯ Low |
| Day time vs. nighttime | 4 | Observational studies | Not serious | Serious[c] | Not serious | Not serious | All plausible residual confounding would suggest a spurious effect, whereas no effect was observed | ⊕⊕◯◯ Low |
| Weekdays vs. weekends | 5 | Observational studies | Not serious | Serious[c] | Not serious | Not serious | All plausible residual confounding would suggest a spurious effect, whereas no effect was observed | ⊕⊕◯◯ Low |

Abbreviation: GRADE, Grading of Recommendations Assessment, Development, and Evaluation.
[a]Two studies were retrospective, and one study was prospective with a very different sample size.
[b]Very few studies published which raises the suspicion of publication bias.
[c]Different sample sizes and timings of studies lead to inconsistency in the results.

unexplored. Also, as the field of pediatric critical care improves, better therapies have decreased the mortality and, hence, other morbidity outcomes are important. We were not able to synthesize other significant patient core outcomes such as length of hospitalization, incidence of renal failure, degree of fluid overload, ventilator-free days, and neurocognitive outcomes.

## Conclusion

Weekday admissions to the PICU were associated with lesser odds of mortality. However, nighttime and off-hour admissions were not associated with increased mortality. An increasing trend toward adopting $24 \times 7$ model has been noted over the years. Overall, quality of evidence reviewed was low. Future studies that adjust for several risk factors are necessary. Also, whether a $24 \times 7$ model really benefits need to be studied prospectively.

### Authors' Contributions

V.W. and N.J. contributed to protocol drafting, search strategy development, acquiring trial reports, trial selection, data extraction, data analysis, data interpretation, reviewing the draft, and future review updates. M.S. and M.J. contributed to protocol drafting, search strategy development, trial selection, data interpretation, reviewing the draft, and future review updates. A.C. contributed to data extraction, analysis and reviewing of the draft. P.P. contributed to search strategy development, executing and managing electronic searches, acquiring trial reports, trial selection, and future review updates.

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### Conflict of interest

None declared.

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